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OFFICE OF
PREVENTION, PESTICIDES AND TOXIC
SUBSTANCES

MEMORANDUM

SUBJECT: Revised Assessment of Percent Commodity Treated Values used in the Registrant's Dietary Exposure Assessment for Fluoride (DP# 361041)

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SUMMARY

The Office of Water (OW) is currently re-evaluating the relative source contribution of fluoride. As part of this assessment, contributions from all sources of fluoride are being examined for the overall exposure of fluoride. The Office of Pesticide Programs (OPP) is providing OW with the pesticidal portion of that overall exposure. This memorandum reviews the post-harvest usage of the fumigant sulfuryl fluoride for incorporation into the Health Effects Division's (HED) report.

In support of characterizing the usage of sulfuryl fluoride, Dow AgroSciences (DAS), the sulfuryl fluoride registrant, has submitted information to refine the dietary exposure originally calculated by HED (EPA, 2004 and 2006). The Biological and Economic Analysis Division (BEAD) evaluated the information provided by DAS and USDA reports. BEAD is providing HED with commodity treated calculations based on methyl bromide usage information. Sulfuryl fluoride is a methyl bromide replacement; however, many of the commodities did not use methyl bromide prior to its phase-out and would be unlikely to use sulfuryl fluoride. BEAD is also providing a comparison of sulfuryl fluoride with aluminum phosphide which is the current market leader in post harvest fumigations.

Sulfuryl fluoride is registered both for direct fumigation of certain commodities and also for fumigation of grain mills and food processing plants where foods may be present and may be indirectly treated. As to direct fumigation, BEAD has assessed usage only those commodities specifically listed on the label as foods that may be directly fumigated with sulfuryl fluoride.

For space fumigations (grain mills and processing plants), BEAD concludes that up to 1.2 % of grains could contain fluoride residues resulting from space treatments. For all other foods (i.e., non-milled grains), the fraction resulting from space treatment is 0.4 %.

For direct treatments to commodities, BEAD has data available for some commodities through applications submitted for the methyl bromide critical use exemption process under the Montreal Protocol. For other crops, limited data are available (e.g., USDA NASS surveys and private market surveys), and BEAD conservatively estimated Percent Commodity Treated based on current and prior methyl bromide usage. Aluminum phosphide, or phosphine, is the dominant fumigant in these markets. It is efficacious, cost-effective, easy to apply, and BEAD does not anticipate a migration from the phosphine market to sulfuryl fluoride. BEAD does, however, anticipate sulfuryl fluoride to replace methyl bromide in these commodity markets. BEAD extrapolates these estimates to other commodities based on similarities in storage, pests, and/or end uses.

The summary of BEAD's estimates of percent commodity treated from direct fumigation is presented in Table 1.

TABLE 1. SUMMARY OF REVISED ESTIMATES OF PERCENT COMMODITY DIRECTLY TREATED WITH SULFURYL FLUORIDE.

BEAD COMMODITY GROUPING	COMMODITY*	PERCENT COMMODITY TREATED*		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
MEATS AND CHEESE	Cheese[1]	0.0 %	0.0 %	0.0 %
	Ham[1]	0.0 %	0.0 %	0.0 %
	Beef (Dried)	0.0 %	0.0 %	0.0 %
QUARANTINED USES[2]	Coconut	0.1 %	0.0 %	0.1 %
	Coffee Bean	0.1 %	0.0 %	0.1 %
	Macadamia Nut	0.1 %	0.0 %	0.1 %
	Ginger	0.1 %	0.0 %	0.1 %

BEAD Commodity Grouping	Commodity*	Percent Commodity Treated*		
		DAS	BEAD	
			Estimate	Recommended
Coarse Grains	Barley[3]	0.1 %	0.1 %	0.1 %
	Corn[6]	0.1 %	0.1 %	0.1 %
	Cottonseed[3]	0.1 %	0.1 %	0.1 %
	Millet[3]	**0.0 %**	**0.1 %**	**0.1 %**
	Oats[6]	0.1 %	0.1 %	0.1 %
	Rice Hulls[3]	**0.0 %**	**0.1 %**	**0.1 %**
	Sorghum[6]	0.1 %	0.1 %	0.1 %
	Triticale[3]	**0.0 %**	**0.1 %**	**0.1 %**
Processed Commodities	Corn – Flour, Grits, Meal	0.1 %	0.0 %	0.1 %
	Herbs And Spices	0.1 %	<0.1 %	0.1 %
	Popcorn	0.1 %	<0.1 %	0.1 %
	Rice – Flour, Bran	3.0 %	0.0 %	3.0 %
	Wheat – Flour, Germ, Bran, Shorts, Milled Byproducts	0.1 %	0.0 %	0.1 %
Stored Commodities	**Peanut[6]**	**0.1 %**	**0.6 %**	**0.6 %**
	Wheat[6]	**0.1 %**	**0.4 %**	**0.4 %**
	Rice[6]	3.0 %	0.9 %	3.0 %
	Wild Rice		0.9 %	3.0 %
Nuts[4]	Almonds	10.0 %	2.2 %	10.0 %
	Beechnut	**0.0 %**	**2.2 %**	**10.0 %**
	Brazil Nut	**0.1 %**	**2.2 %**	**10.0 %**
	Butternut	**0.0 %**	**2.2 %**	**10.0 %**
	Cashew	**0.1 %**	**2.2 %**	**10.0 %**
	Chestnut	**0.1 %**	**2.2 %**	**10.0 %**
	Chinquapin	**0.0 %**	**2.2 %**	**10.0 %**
	Filbert	**0.1 %**	**2.2 %**	**10.0 %**
	Hickory Nut	**0.1 %**	**2.2 %**	**10.0 %**
	Pecans	**0.1 %**	**2.2 %**	**10.0 %**
	Pine Nut	**0.1 %**	**2.2 %**	**10.0 %**
Methyl Bromide Critical Use Exemption Commodities	**Pistachio[1]**	**0.1 %**	**27.0 %**	**27.0 %**
	Walnuts[1]	**20.0 %**	**99.0 %**	**99.0 %**
	Dates[1]	**40.0 %**	**42.0 %**	**42.0 %**
	Prunes, Raisins, Figs[1]	**40.0 %**	**69.0 %**	**69.0 %**
	Other Dried Fruit[5, 7]	**0.1 %**	**69.0 %**	**69.0 %**
	Dried Beans[1]	100.0 %	92.0 %	100.0 %
	Legumes (Dried, except Chickpea & Cowpea)[5, 7]	**0.1 %**	**92.0 %**	**100.0 %**
	Cocoa Beans[1]	100.0 %	100.0 %	100.0 %

* Bolded text indicates BEAD's recommendations are higher than DAS estimates.

1. Based on BEAD calculations from comparative methyl bromide usage.
2. Currently fumigated with methyl bromide to fulfill federal or state quarantine requirements.
3. Estimates based on PCT for sorghum and oats. BEAD assumes similar categorization of small coarse grains.
4. This group did not request a methyl bromide CUE and BEAD is anticipating sulfuryl fluoride to replace methyl bromide. BEAD estimates PCT to be no more than the DAS estimate for almonds. Based on the pest spectrum, nuts are primarily treated with phosphine, with some treated with Propylene Oxide.
5. Based on estimates from similar methyl bromide critical use exemption commodities
6. Based on reports of methyl bromide usage by USDA NASS
7. BEAD's estimate is based on a commodity with a similar use pattern; therefore BEAD defaults to the higher of the two estimates of the original commodity.

BACKGROUND

Sulfuryl fluoride is a biocide fumigant that is used to kill insect pests, rodents, birds, and snakes within facilities as well as commodities. Sulfuryl fluoride was initially registered as Vikane®, a fumigant to treat drywood termites and other wood boring insects in 1959. It was identified as a potential alternative for post-harvest uses of methyl bromide, which is being phased out, in accordance with the Montreal Protocol on ozone-depleting substances. In 2004, USEPA registered a sulfuryl fluoride product, ProFume®, a fumigant to treat food processing facilities, cereal grains, tree nuts, and dried fruit. As noted above, DAS is the sole registrant for this product. In the summer of 2005, USEPA granted DAS' request to expand its sulfuryl fluoride food use registrations to essentially match the methyl bromide label for commodity fumigations.

Sulfuryl fluoride is stored in standardized, compressed gas containers, which are placed outside the structure. Gas is introduced from the cylinder through a suitable leak-proof tube with a minimum burst pressure of 3450 kPa (500 psi). Release of the fumigant into a large open space is recommended. The label for sulfuryl fluoride requires the use of electric fans to provide forced air circulation for facilitating rapid dispersion of the fumigant during its introduction into spaces or air recirculation through commodity fumigation.

Sulfuryl fluoride's label requires the use of a DAS computer program, designated as the Fumiguide®, which calculates the application rate based on the pest, life stage, temperature, and exposure period for specific fumigation scenarios. Because the Fumiguide is part of the pesticide label, it is unlawful under FIFRA to use sulfuryl fluoride in a manner inconsistent with the Fumiguide. Monitoring concentrations throughout the fumigation is required and concentrations are input into the Fumiguide®, which will calculate the actual half-life time and any additional amount of fumigant and/or increase in exposure time necessary. In addition, sulfuryl fluoride fumigations require a minimum of two trained and certified applicators, at least one of whom must be a licensed fumigator, at the treatment site for the duration of the application and aeration. Licensed fumigators may be available at large grain storage facilities, but typically, work for fumigation companies.

Sulfuryl fluoride retails for about $5.00 per pound. Application rates for commodities vary widely, and chemical costs may range from $15 to $50 for 1,000 bushels.

Sulfuryl fluoride is expected to take over most of the methyl bromide post-harvest market, as methyl bromide is phased out. Like sulfuryl fluoride, methyl bromide is available as a compressed gas stored in standardized cylinders. Fumigation with methyl bromide does not require a computer program like the Fumiguide®. Both fumigants target essentially the same pests although there are some differences. The efficacy of sulfuryl fluoride is more sensitive to temperature than methyl bromide. The chemical costs for both chemicals are similar for fumigation at high temperatures, but lower temperatures require more sulfuryl fluoride. Methyl bromide and sulfuryl fluoride are used when rapid fumigation is needed, or in locations where silver and copper metals and their alloys occur (primarily in electrical and computer systems in mills and processing facilities) as methyl bromide and sulfuryl fluoride are non-corrosive.

The other major fumigant in the market is aluminum phosphide, or phosphine. Sulfuryl fluoride is not anticipated to replace any aluminum phosphide fumigations because aluminum phosphide is efficacious for the same pests, easy to use, and inexpensive. It is manufactured as tablets or pellets that slowly react with atmospheric moisture to produce phosphine gas. Aluminum phosphide is the most widely used post harvest fumigant for stored commodities such as corn, oats, peanuts, rice, sorghum, and wheat. It can be inserted into the stored grain by a plunger or can be added as the grain is being binned. The bin is closed or the surface of the grain is covered by plastic tarpaulin. Fumigation takes five to seven days.

The aluminum phosphide label requires two persons, at least one of whom is a certified applicator, to be present when pellets/tablets are introduced and again at the end of aeration, but a fumigator's license is not required. Some farmers may be certified applicators and could conduct their own aluminum phosphide applications on farm. It is also relatively low cost. Aluminum phosphide retails from $5 to $10 per pound. Application rates vary between 0.26 to 1.00 pound per 1,000 bushes of grain, thereby costing anywhere from $1.30 to $10 in chemical costs for 1,000 bushels.

Aluminum phosphide is seldom used to fumigate food processing facilities or mills, however, unless it is done in small, confined areas. It is corrosive to metals and would damage equipment, particularly components of sensitive computerized systems. In addition the time required for fumigation with aluminum phosphide is a major drawback to its use as closing facilities for up to a week would have substantial impacts on production.

Another fumigant used for some commodities is propylene oxide (PPO). It is often used to control a variety of microbial pests that are not affected by methyl bromide or sulfuryl fluoride. A combination of aluminum phosphide and PPO work very well for many nuts and dried beans.

Food processors have significantly reduced their reliance on fumigation in the last couple of decades. Their first line of defense is integrated pest management, especially sanitation, and equipment design modifications to enable cleaning and inspection in all areas of a facility. Facilities are now being monitored for pest populations, using visual inspections, pheromone traps, light traps, and electrocution traps. When insect pests are found, facilities will attempt to contain the infestation with treatments of low volatility pesticides applied to both surfaces and cracks and crevices; spot treatments with heat or phosphine will be used in areas that are suitable. Incoming ingredients are inspected for insect pests and may be treated with phosphine if temperature and time are sufficient, or contaminated ingredients may be rejected. These techniques do not disinfest a facility but are critical in monitoring and managing pests, and hopefully preventing outbreaks. However, when all these methods fail to control a pest problem, facilities must rely on fumigation, to kill pests within the processing equipment, bins, storage spaces and even the walls of the structure.

Most grain is not directly treated with pesticides. Pest control in grain storage is primarily by cleaning empty bins, aerating ducts, and by removing spilled grain and vegetation near the bins. Typically bins are treated when they are empty, either with a fumigant, a liquid insecticide, or diatomaceous earth. Grain may be treated as it is augured into a storage bin or after it is in a grain bin. If treated, the commonly used insecticides are cyfluthrin, chlorpyrifos methyl,

pirimiphos methyl, and malathion. Grain in storage is mainly treated with aeration devices, often with chilling, especially at off-farm storage facilities. Or grain in storage may be fumigated, usually with aluminum phosphide.

The food usage of sulfuryl fluoride is currently low, with some exceptions, but the situation is dynamic. Methyl bromide is available for the post-harvest sector only through the critical use exemption (CUE) process of the Montreal Protocol and is being greatly reduced each year. For this memorandum, BEAD estimates that sulfuryl fluoride replaces all methyl bromide post-harvest uses other than the quarantine use. Sulfuryl fluoride is currently not a contender for the quarantine commodity uses of methyl bromide, which are exempt from the Montreal Protocol, and it has not yet met the phytosanitary conditions established by the International Plant Protection Convention.

SPACE FUMIGATIONS (GRAIN MILLS AND PROCESSING PLANTS)

Residues may be left on commodities if they are present in a mill or processing plant at the time of fumigation. The proportion of commodities present during a fumigation depends on the proportion of facilities treated, the frequency of treatments, and the proportion of annual product present during the fumigation period. BEAD estimates this as follows:

PCT (Space Treatments) = PFT * NF * (DF / TOD)

Where:

- PCT (Space Treatments) is the estimated percent of commodities exposed during fumigation, PFT is the percent of facilities treated,
- NF is the average number of fumigations per year,
- DF is the duration of a fumigation, and
- TOD is the total operating days of the facilities.

This method results in a conservative estimate of the percent of commodities exposed because the ratio of fumigation duration to total days of operation overstates the proportion of annual product present during fumigation. First, fumigations may be limited to specific areas of a plant or mill that are isolated from on-going production. Second, if the majority of the plant is to be fumigated, facilities will halt production during fumigation and most will slow, if not clear, production lines prior to shutting down for fumigation, reducing the amount of product that may be exposed relative to average daily production.

BEAD and DAS agree with the following parameters: percent of the facilities treated (40%), number of days of production held in facility during a fumigation (2 days for grain mills; 1 day for processing facilities) and the number of fumigations per year (3 per year for grain mills; 2.5 per year for processing facilities).

However, BEAD and DAS differ on the number of operating days per year at grain mills and processing plants. DAS assumes that these facilities are in operation 350 days per year, based on "consultation with operators." BEAD originally assumed that these facilities operate 300 days per year because facilities do not operate at 100% capacity year round (Becker, et al. 2005).

Manufacturers need to repair or service machinery, so portions of a production may temporarily go offline. A few facilities do not operate year round. To maintain a conservative estimate, BEAD retains this assumption; although, the difference in estimated percent of commodity exposed is small. In addition, BEAD rounds up to the nearest 0.1% in order to be conservative. Table 2 presents DAS and BEAD estimates.

TABLE 2. ESTIMATED PERCENT COMMODITY EXPOSED DURING STRUCTURAL FUMIGATION.

STRUCTURE	DAS	BEAD
Grain Mills	0.7%	0.8%
Food Processing Facilities	0.3%	0.4%
Total (Grain)	1.0%	1.2%

BEAD agrees with DAS that treatments occurring in the mills and food processing facilities are independent. Thus up to 1.2% of grains could contain fluoride residues resulting from space treatments (i.e., 0.8% from treatment in mills and 0.4% from treatment in processing facilities). For all other foods (i.e., non-milled grains), the fraction resulting from space treatment is 0.4 %.

DIRECT FOOD TREATMENTS

DAS Methodology

DAS derived percent crop treated estimates for seven commodities that are directly treated (almonds, cocoa, corn, popcorn, prunes, rice and wheat). Their approach is as follows:

$$PCT\ (Commodity) = [VT*(1-0.1)]*\rho\ /\ (FAPC*US\ pop)$$

Where:

- PCT (Commodity) is the estimated percent of a commodity directly treated with sulfuryl fluoride,
- VT is the volume of the commodity treated,
- ρ is the bulk density of the commodity,
- FACP is Food Availability Per Capita, and
- US pop is the population of the United States.

Fumigators using sulfuryl fluoride report to DAS the volume of commodities treated via the Fumiguide®. DAS then adjusts this value downward by 10 % to account for incomplete filling of the fumigation bin. Total volume treated is multiplied by the bulk density of the commodity to estimate the weight of treated commodity. Food Availability Per Capita is obtained from USDA/ERS (http://www.ers.usda.gov/Data/FoodConsumption/FoodAvailIndex.htm) and is calculated as the sum of total annual production, imports, and beginning stocks of a particular commodity less exports, ending stocks, and non-food uses, divided by U.S. population. Thus, multiplying this amount by U.S. population returns the total amount of a commodity available for food consumption in a year but does not account for spoilage or waste. This method is a reasonably conservative approach for commodities with significant use as animal feed, since feed may also be fumigated, and very conservative for commodities with significant exports, as they are also likely to be fumigated.

BEAD has some concerns over the data used in the DAS estimates, including:

- Company data are incomplete for many of the seven commodities. In recent years, fumigators have not submitted complete reports of usage and commodities treated.
- There are limited data on how full each bin is when the fumigation occurs. The label requires some active aeration during fumigation, but this does not prevent bins from being completely filled.

BEAD Methodology

BEAD usually estimates a percent crop or commodity treated for new insecticides or new uses as the average and/or observed maximum Percent Crop Treated of the market leader, which is the most widely used insecticide for that crop. These initial estimates do not consider target pests or specifics of the chemical. Analysis has shown that new chemicals rarely overtake the market leader by crop site and pesticide type within 5 years, i.e. less than 2% of the time (Keigwin, 2006). Data are primarily from USDA/ NASS and California Department of Pesticide Regulation. BEAD also uses EPA proprietary data to supplement data gaps. These data are direct reports of percent crop treated, and not calculated from volumes. An average of the highest "area applied" percentages for the last three years for each site is then used.

However, in this case, sulfuryl fluoride has been registered for food uses for 5 years. Its pest spectrum and chemistry is well-known. It is comparable to methyl bromide and not the post-harvest market leader (aluminum phosphide), for reasons previously described in the Background section of this document. Therefore, BEAD uses the historic values for methyl bromide as the percent of the commodity that may be treated with sulfuryl fluoride, unless otherwise stated in the specific commodity sections below. Due to the phaseout of methyl bromide, BEAD also uses data from the methyl bromide CUE process. For the purpose of estimating percent of commodity treated for dietary risk assessment, to be conservative, BEAD's recommended estimate is the higher of either BEAD's likely estimate or DAS's estimate. In addition, in certain circumstances, when the estimate is based on a commodity with a similar use pattern, BEAD defaults to the higher of the two estimates of the original commodity.

Commodities

Sulfuryl fluoride is registered on an extensive list of commodities. The following tables have commodities with the percent crop treated as proposed by DAS based on their proposed methodology and Fumiguide® data from 2004-2007. Sulfuryl fluoride is a methyl bromide replacement, and many of the commodities did not use methyl bromide prior to its phase-out. BEAD has data available for some commodities through applications submitted for the methyl bromide critical use exemption process. For other crops, limited data are available (e.g., USDA NASS surveys and private market surveys), and BEAD conservatively estimated Percent Commodity Treated to equal current or prior methyl bromide usage. Aluminum phosphide, or phosphine, is the dominant fumigant in these markets. It is efficacious, cost-effective, and easy to apply; therefore BEAD does not anticipate a migration from the phosphine market to sulfuryl fluoride. BEAD does, however, anticipate sulfuryl fluoride to replace methyl bromide in these commodity markets.

Meats and Cheese

DAS is anticipating zero percent commodity treated on the following commodities: cheese and ham. BEAD can confirm that these two commodities are not likely to undergo sulfuryl fluoride treatment (Table 3). These commodities are part of the Methyl Bromide Critical Use Exemption Process and have demonstrated critical need because there are no alternatives for the key pests. BEAD agrees that sulfuryl fluoride will not be used on cheese and ham based on data demonstrating no efficacy on the target pests in these commodities (Phillips, et al. 2008). BEAD also agrees that sulfuryl fluoride will not be used on dried meat (beef) because it is processed and packaged in such a way to minimize pest infestations and therefore not fumigated (Table 3).

TABLE 3. REVISED ESTIMATES OF PERCENT MEATS AND CHEESES TREATED WITH SULFURYL FLUORIDE

BEAD COMMODITY GROUPING	COMMODITY	PERCENT COMMODITY TREATED		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
MEATS AND CHEESE	Cheese[1]	0.0 %	0.0 %	0.0 %
	Ham[1]	0.0 %	0.0 %	0.0 %
	Beef (Dried)	0.0 %	0.0 %	0.0 %

1. Based on BEAD calculations from comparative methyl bromide usage.

Quarantine Uses

According to their Fumiguide®, DAS has had no documented uses on coconut, coffee bean, ginger, and macadamia nut in the last four years. They are proposing 0.1% as a conservative estimate for those commodities. Coconut is imported into the USA and requires quarantine fumigation. USDA APHIS, in their treatment manual, requires methyl bromide to be used in these fumigations. The other commodities have state (primarily Hawaii and California) quarantine requirements. BEAD does not expect sulfuryl fluoride to replace quarantine uses of methyl bromide, because these uses have a special exemption under the Montreal Protocol (Table 4). In addition, sulfuryl fluoride has not yet met the phytosanitary conditions established by the International Plant Protection Convention to meet quarantine requirements. Therefore BEAD does not expect sulfuryl fluoride to displace methyl bromide quarantine uses. BEAD believes it is likely that zero percent commodity will be treated. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of using the higher of the two estimates, BEAD conservatively recommends 0.1% commodity treated for coconut, coffee bean, ginger, and macadamia nut.

TABLE 4. REVISED ESTIMATES OF PERCENT QUARANTINE USES TREATED WITH SULFURYL FLUORIDE

BEAD COMMODITY GROUPING	COMMODITY	PERCENT COMMODITY TREATED		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
QUARANTINED USES[1]	Coconut	0.1 %	0.0 %	0.1 %
	Coffee Bean	0.1 %	0.0 %	0.1 %
	Macadamia Nut	0.1 %	0.0 %	0.1 %
	Ginger	0.1 %	0.0 %	0.1 %

1. Currently fumigated with methyl bromide to fulfill federal or state quarantine requirements.

Coarse Grains

DAS has no documented fumigation on cottonseed, oats, sorghum, barley according to the last four years of Fumiguide® data. DAS has documentation of fumigation on a very small amount of corn in 2004. DAS has proposed that the following commodities be assessed at 0.1% commodity treated: cottonseed, oats, sorghum, barley, and corn. DAS also has not documented sulfuryl fluoride fumigation of millet, rice hulls and triticale. DAS does not anticipate any use and estimates 0% commodity treated for these commodities.

USDA data are available for fumigant use on corn, sorghum, and oats. Based on these usage data and the similar use patterns for cottonseed, oats, sorghum, barley and corn, BEAD believes that the DAS estimate for these grains of 0.1% is conservative. BEAD's analysis of the data on corn, sorghum, and oats is discussed below. Since millet, rice hulls, and triticale are also coarse grains with similar pest spectrum and uses to oats, sorghum, barley and corn, BEAD expects the usage of sulfuryl fluoride to be similar. Therefore, BEAD has used 0.1% as a conservative estimate (Table 5).

Corn

DAS estimates a percent commodity treated for corn of 0.1%. Based on available data covering historic methyl bromide use patterns, BEAD believes that this is a conservative estimate.

As indicated in the Background section, most stored grain is not treated with insecticides. BEAD estimates less than 7% are treated with insecticides based on EPA private market data and USDA NASS data. To the extent that stored corn is treated with an insecticide, the most recent USDA data from 2004 indicate that the most widely used insecticide is the fumigant aluminum phosphide (NASS, 2004). USDA reports that aluminum phosphide was used on 97% of the volume treated with an insecticide. Aluminum phosphide is efficacious, cost-effective, easy to apply, and BEAD does not anticipate a migration from the aluminum phosphide market to sulfuryl fluoride. BEAD does, however, anticipate that sulfuryl fluoride will replace methyl bromide in this market. USDA data indicate that methyl bromide was used in the 2002 marketing year on corn; however, USDA reports the usage as so low that a numerical estimate is not provided. USDA does not make a numerical estimate when usage is so infrequent that reporting a number may compromise the confidentiality of the survey. The 2002 methyl bromide data are a conservative estimate for sulfuryl fluoride usage because these data are prior to the conclusion of the phaseout of methyl bromide when methyl bromide was readily available. Accordingly, BEAD believes that the recommended estimate of sulfuryl fluoride use of 0.1% is conservative.

Sorghum and Oats

DAS estimates a percent commodity treated for sorghum and oats of 0.1%. Based on available data covering insecticide use on stored sorghum and oats and historic methyl bromide use patterns, BEAD believes that this is a conservative estimate.

As indicated in the Background section, most stored grain is not treated with insecticides. According to USDA data (NASS, 2007) 6% of stored oats are treated with an insecticide.

Similarly, according to USDA data (NASS, 2001) 4% of stored sorghum are treated with an insecticide. To the extent that stored sorghum and oats are treated with an insecticide, the most recent USDA data from 2001 and 2007 indicate that the most widely used insecticide is the fumigant aluminum phosphide. USDA reports that aluminum phosphide was used on 77% of stored sorghum and 86% of stored oats of the volume treated with an insecticide. Aluminum phosphide, or phosphine, is efficacious and cost-effective and BEAD does not anticipate a migration from the phosphine market to sulfuryl fluoride. BEAD does, however, anticipate that sulfuryl fluoride will replace methyl bromide in this market. USDA data indicate that methyl bromide was used in the 1999 and 2005/06 marketing year on stored sorghum and oats, respectively; however, USDA reports the usage as so low that a numerical estimate is not provided. USDA does not make a numerical estimate when usage is so infrequent that reporting a number may compromise the confidentiality of the survey. Accordingly, BEAD believes that recommended estimate of sulfuryl fluoride use of 0.1% is conservative.

TABLE 5. REVISED ESTIMATES OF PERCENT COARSE GRAINS USED TREATED WITH SULFURYL FLUORIDE.

BEAD COMMODITY GROUPING	COMMODITY*	PERCENT COMMODITY TREATED*		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
COARSE GRAINS	Barley[2]	0.1 %	0.1 %	0.1 %
	Corn[1]	0.1 %	0.1 %	0.1 %
	Cottonseed[2]	0.1 %	0.1 %	0.1 %
	Millet[2]	**0.0 %**	**0.1 %**	**0.1 %**
	Oats[1]	0.1 %	0.1 %	0.1 %
	Rice Hulls[2]	**0.0 %**	**0.1 %**	**0.1 %**
	Sorghum[1]	0.1 %	0.1 %	0.1 %
	Triticale[2]	**0.0 %**	**0.1 %**	**0.1 %**

* Bolded text indicates BEAD's recommendations are higher than DAS estimates.
1. Based on reports of methyl bromide by USDA NASS.
2. Estimates based on PCT for sorghum and oats. BEAD assumes similar categorization of small coarse grains.

Processed Commodities

Processed foods are not likely to get fumigated with sulfuryl fluoride. After commodities are processed they are shipped to storage warehouses, where sanitation is critical. Processed commodities are inspected, both the commodity and their packaging material, upon receipt at a warehouse. Sanitation and other IPM strategies are used to prevent infestation of processed foods (see Background Section). However, if any processed food is contaminated, pests either on or within the packaging, it will be removed for destruction or fumigated. The fumigant of choice in these situations is phosphine because it is efficacious, easy to use and cost effective (Mason, personal communication, 2009; Hui, et al. 2003).

DAS has evidence of direct treatment on popcorn. As a result, DAS estimated that popcorn might get fumigated and calculated 0.1% commodity treated. Given how processed goods are handled, BEAD believes the direct treatment of popcorn is an anomaly and possibly the result of labeling a space treatment by the commodity that was to be stored in the treated space. Moreover, BEAD would typically average usage of a registered product across several data points, rather than using the maximum observed. Thus, BEAD estimates usage at much less than 0.1%. In keeping with BEAD's methodology to be conservative, however, BEAD recommends using 0.1% commodity treated for popcorn.

DAS also anticipates fumigating a small proportion of herbs and spices based on past methyl bromide CUE requests. However, past requests for methyl bromide were for space treatments of areas used to process or store herbs and spices, not for direct treatments. Processors of herbs and spices ceased use of methyl bromide well before the conclusion of the phaseout of methyl bromide, and fumigate with either PPO or ethylene oxide to control microbial pests. Therefore BEAD estimates much less than 0.1 percent crop treated. However, to be conservative, BEAD recommends using 0.1% commodity treated, which is the higher of the two estimates.

DAS estimated 0.1% commodity treated for corn flour, corn grits, corn meal, wheat flour, wheat germ, wheat bran, wheat milled byproducts and wheat shorts (Table 6). These estimates are extrapolated from DAS estimates of the treated grain (see Table 7) rather than evidence of direct treatments of the processed forms.

BEAD anticipates that the following processed commodities (corn flour, corn grits, corn meal, wheat flour, wheat germ and wheat bran, wheat shorts and wheat milled byproducts) will not be treated as a direct commodity fumigation (zero percent crop treated). As previously indicated, to the extent processed commodities such as these become infested, they are either destroyed or fumigated with phosphine. There is no evidence of methyl bromide use on these commodities to address infestation either from pre-methyl bromide phaseout data or in terms of CUE requests after conclusion of the phaseout. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of using the higher of the two estimates, BEAD conservatively recommends 0.1% commodity treated for the processed commodities for direct fumigations (Table 6).

DAS estimated that rice flour and rice bran would be treated at 3% commodity treated; however, BEAD does not think this estimate is reasonable as it was extrapolated from the rice grain estimate without regard to how processed commodities are treated. BEAD categorizes this commodity as a processed commodity and believes it is likely that zero percent commodity will be treated as a direct commodity fumigation for the reasons given above as to processed grain commodities. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of using the higher of the two estimates, BEAD conservatively recommends 3.0 % commodity treated for rice flour and rice bran for direct fumigations (Table 6).

TABLE 6. REVISED ESTIMATES OF PERCENT PROCESSED COMMODITIES TREATED WITH SULFURYL FLUORIDE.

BEAD COMMODITY GROUPING	COMMODITY	PERCENT COMMODITY TREATED		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
PROCESSED COMMODITIES	Corn – Flour, Grits, Meal	0.1 %	0.0 %	0.1 %
	Herbs And Spices	0.1 %	<0.1 %	0.1 %
	Popcorn	0.1 %	<0.1 %	0.1 %
	Rice – Flour, Bran[2]	3.0 %	0.0 %	3.0 %
	Wheat – Flour, Germ, Bran, Shorts, Milled byproducts	0.1 %	0.0 %	0.1 %

1. Estimates based on assumption that these commodities are treated as a result of space fumigations and not direct commodity fumigations.
2. BEAD assumes these uses are miscategorized by DAS according to similar commodity type and not by use pattern.

Stored Commodities

Based on their Fumiguide® data, DAS estimated a percent commodity treated for stored peanuts and wheat of 0.1%, and rice of 3%. BEAD's analysis for these commodities is explained below.

Peanuts

DAS estimates 0.1% crop treated for stored peanuts. BEAD recommends the estimate of stored peanuts that may be treated with sulfuryl fluoride to be 0.6% based on available data regarding methyl bromide use.

As indicated in the Background section, most stored peanuts are not treated with insecticides. USDA (2006) estimates that 33% of peanuts stored off-farm is treated with an insecticide (see Background section for explanation on why on-farm fumigation is unlikely). To the extent stored peanuts are treated with an insecticide, the most recent USDA data from 2006 indicate that the most widely used insecticide in stored peanuts is the fumigant aluminum phosphide. USDA reports that aluminum phosphide was used on 73% of the volume treated with an insecticide. Aluminum phosphide is efficacious, cost-effective, easy to apply, and BEAD does not anticipate a migration from the phosphine market to sulfuryl fluoride. BEAD does, however, anticipate that sulfuryl fluoride will replace the methyl bromide in this market. USDA (2001) data also indicate that methyl bromide was used on 0.6% of stored peanuts for the 1999 marketing year. The 1999 methyl bromide data are a conservative estimate for sulfuryl fluoride usage because these data are before the conclusion of the phaseout of methyl bromide when methyl bromide was readily available. Moreover, there have been no CUE requests for methyl bromide on peanuts under the Montreal Protocol. Accordingly, BEAD estimates that the percent of stored peanuts treated with sulfuryl fluoride to be 0.6% (Table 7).

Wheat

DAS estimated a percent commodity treated for wheat of 0.1%. BEAD recommends the estimate of wheat that may be treated with sulfuryl fluoride to be 0.4% based on available data regarding methyl bromide use.

As indicated in the Background section, most stored grain is not treated with insecticides. The amount of wheat treated with insecticide for both off-farm and on-farm use is estimated to be approximately 30%, based on EPA market data and USDA reports of the

volume of off-farm stored wheat handled (NASS, 2002). To the extent that stored wheat is treated with an insecticide, the most recent USDA data from 2002 indicate that the most widely used insecticide is the fumigant aluminum phosphide. USDA reports that aluminum phosphide was used on 87% of the volume treated with an insecticide. Aluminum phosphide, or phosphine, is efficacious, cost-effective, easy to apply, and BEAD does not anticipate a migration from the phosphine market to sulfuryl fluoride. BEAD does, however, anticipate that sulfuryl fluoride will replace the methyl bromide in this market. USDA data also indicate that methyl bromide was used on 0.4% of stored wheat for both 1997 and 2000 marketing years. The 1997 and 2000 methyl bromide data are a conservative estimate for sulfuryl fluoride usage because these data are before the conclusion of the phaseout of methyl bromide when methyl bromide was readily available. Moreover, there have been no CUE requests for methyl bromide on wheat under the Montreal Protocol. Accordingly, BEAD estimates that the percent of wheat treated with sulfuryl fluoride to be 0.4% (Table 7).

Rice

For rice, DAS has data documenting use on 0.14 to 2.5% of rice with an average PCT of 0.8%. DAS estimated a percent commodity treated for rice of 3.0% based on anticipated future potential expansion into the rice, brown rice, and wild rice markets and rounding up from their maximum estimate. DAS's maximum estimate is from 2006, the year after methyl bromide was phased out and BEAD believes that this was a trial period and many rice companies tried sulfuryl fluoride. In 2004 and 2005 there were 4 to 6 fumigations on rice, in 2006 there were 45 fumigations, and in 2007 there were 6 fumigations. BEAD considers the one year spike an anomaly and does not anticipate usage to reach that level in the future. Based on historic methyl bromide use patterns; BEAD believes 3.0 % is a very conservative estimate.

As indicated in the Background section, most stored grain is not treated with insecticides. Total off-farm stored rice treated with all insecticides is estimated at 21% for rough rice and 23% for processed rice (NASS, 2001). EPA proprietary data suggests that most rice is stored off-farm and that a larger proportion of off-farm stored rice is treated with an insecticide than on-farm stored rice. However, the data are sparse and, to be conservative, BEAD assumes similar proportions are treated. Based on these limited data, a conservative estimate of the amount of off-farm rice treated with an insecticide is approximately 23%. To the extent that stored rice is treated with an insecticide, the most recent USDA data indicates that the most widely used insecticide is the fumigant aluminum phosphide. USDA reports that aluminum phosphide was used on 97% of the volume treated with an insecticide. Aluminum phosphide, or phosphine, is efficacious and cost-effective and BEAD does not anticipate a migration from the phosphine market to sulfuryl fluoride. BEAD does, however, anticipate that sulfuryl fluoride will replace methyl bromide in this market. USDA data indicate that there is some use of methyl bromide in the 1999 marketing year on processed rice; however, USDA reports the usage as so low that a numerical estimate is not provided. USDA does not make a numerical estimate when usage is so infrequent that reporting a number may compromise the confidentiality of the survey.

DAS data represent the best available estimates of the amount of rice treated with sulfuryl fluoride. To account for the possibility that chambers are completely filled, however, BEAD increases the volume treated by 10%. BEAD does not make an adjustment for the total rice available for food consumption as rice is not subject to significant spoilage or wastage. Once dried, rice is easy to store for long. Therefore, BEAD estimates about 0.9 percent commodity treated. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of using the higher of the two estimates, BEAD conservatively recommends 3.0 % commodity treated on rice (Table 7).

In the absence of data specific to wild rice, BEAD assumes it will be treated like other small grains, including wheat, barley, rye, and rice. To be conservative, BEAD extrapolates from the highest estimate among these commodities, rice, to be used for wild rice (Table 7).

TABLE 7. REVISED ESTIMATES OF PERCENT STORED COMMODITIES TREATED WITH SULFURYL FLUORIDE.

BEAD COMMODITY GROUPING	COMMODITY*	PERCENT COMMODITY TREATED*		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
STORED COMMODITIES	**Peanut**[1]	**0.1 %**	**0.6 %**	**0.6 %**
	Wheat[1]	**0.1 %**	**0.4 %**	**0.4 %**
	Rice[1]	3.0 %	0.9 %	3.0 %
	Wild Rice[2]		0.9 %	3.0 %

* Bolded text indicates BEAD's recommendations are higher than DAS estimates.
1. Based on reports of methyl bromide usage by USDA NASS
2. DAS grouped with rice.

Nuts

Based on the pest spectrum, nuts are primarily a phosphine market, with some treated with PPO. DAS has documented fumigations of almonds in the last four years, which DAS estimates to range from 3.1 to 8.3% commodity treated with an average PCT of 6.0%. DAS estimated a percent commodity treated for almonds of 10% based on anticipated future potential expansion into the almond market and rounding up from their maximum estimate. DAS methodology results in a very conservative estimate in this situation because they calculate PCT assuming that total sulfuryl fluoride usage on almonds is used only on almonds available for domestic consumption. However, nearly 80% of U.S. almond production is exported (FAS, 2008) and there is no reason to believe that exports are less likely to be fumigated with sulfuryl fluoride than almonds destined for the domestic market. DAS data represent the best available information on amount treated. To estimate percent commodity treated, BEAD calculates the average quantity treated based on DAS data, which BEAD increases by 10% to account for complete fill of fumigation chambers, and divides by average utilized production, which is total production less culls and storage losses (NASS, 2008). This results in a BEAD estimate of 2.2% commodity treated for almonds. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of using the higher of the two estimates, BEAD conservatively recommends 10% commodity treated on almonds (Table 8).

Based on the similarity of the following commodities to almonds (i.e., they are all tree nuts), BEAD estimates 2.2% commodity treated for beechnut, butternut, Brazil nut, cashews, chestnuts,

chinquapin, filberts, hickory nuts, pecans, and pine nuts. DAS anticipated zero usage for beechnut, butternut, and chinquapin and 0.1% usage for Brazil nut, cashews, chestnuts, filberts, hickory nuts, pecans, and pine nuts. These groups did not request a methyl bromide CUE and BEAD is not anticipating sulfuryl fluoride will penetrate this market other than as serving as a methyl bromide replacement. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology, we recommend defaulting to the higher of the two estimates. In this case, since all estimates are based on data from almonds, BEAD conservatively recommends 10% commodity treated on beechnut, butternut, chinquapin, Brazil nut, cashews, chestnuts, filberts, hickory nuts, pecans, and pine nuts (Table 8).

TABLE 8. REVISED ESTIMATES OF PERCENT NUTS TREATED WITH SULFURYL FLUORIDE

BEAD COMMODITY GROUPING	COMMODITY*	PERCENT COMMODITY TREATED*		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
NUTS[1]	Almonds	10.0 %	2.2 %	10.0 %
	Beechnut[2]	**0.0 %**	**2.2 %**	**10.0 %**
	Brazil Nut[2]	**0.1 %**	**2.2 %**	**10.0 %**
	Butternut[2]	**0.0 %**	**2.2 %**	**10.0 %**
	Cashew[2]	**0.1 %**	**2.2 %**	**10.0 %**
	Chestnut[2]	**0.1 %**	**2.2 %**	**10.0 %**
	Chinquapin[2]	**0.0 %**	**2.2 %**	**10.0 %**
	Filbert[2]	**0.1 %**	**2.2 %**	**10.0 %**
	Hickory Nut[2]	**0.1 %**	**2.2 %**	**10.0 %**
	Pecans[2]	**0.1 %**	**2.2 %**	**10.0 %**
	Pine Nut[2]	**0.1 %**	**2.2 %**	**10.0 %**

* Bolded text indicates BEAD's recommendations are higher than DAS estimates.
1. This group did not request a methyl bromide CUE. Based on the pest spectrum, nuts are primarily treated with phosphine, with some treated with Propylene Oxide.
2. BEAD's estimate is based on a commodity with a similar use pattern; therefore BEAD defaults to the higher of the two estimates of the original commodity.

Methyl Bromide Critical Use Exemption Commodities (CUE)

Several commodity groups have requested a methyl bromide CUE each year since the phase-out of methyl bromide (Table 9). These commodities are walnuts, raisins, prunes, figs, dried beans, and dates. Pistachios requested a methyl bromide CUE for the first three years of the process.

Table 9 contains the calculations of BEAD's best estimate of the projection of sulfuryl fluoride percent crop treated for these commodities. Estimates are based on the difference between the applicant-requested amount of methyl bromide and the final nominated amount granted for critical use of methyl bromide. BEAD assumes the gap between the amount requested and the amount nominated would reflect the portion of the sulfuryl fluoride use on that commodity because sulfuryl fluoride is a methyl bromide replacement. For example, the applicant requested amount of methyl bromide for prunes, raisins, and figs was 20,412 kg and the final nominated amount granted for this critical use was 6,266 kg. Accordingly, methyl bromide is projected to be used on 31% of the prunes, raisins, and figs so the remaining 69% could be treated with sulfuryl fluoride.

BEAD's approach to estimating percent crop treated for these commodities is conservative for two reasons. First, the portion of the requested amount of methyl bromide not granted as a CUE is unlikely to be replaced fully by sulfuryl fluoride given the availability of other methyl bromide alternatives, including phosphine. Second, the approach assumes that the entire commodity (100% crop treated) is currently treated with methyl bromide, which is unlikely to be the case. Not only would it be uncommon for the entire commodity to be fumigated but other fumigants (e.g., phosphine) are likely to be used in circumstances where speed of fumigation is not essential.

Sulfuryl fluoride is unlikely to replace any methyl bromide use granted as a CUE given both the general advantages of methyl bromide over sulfuryl fluoride (see Background) and the fact that resources required to obtain a CUE demonstrate a strong preference for methyl bromide.

For nearly all commodities, BEAD estimates higher percent commodity treated than does DAS and recommends using BEAD's estimates in the dietary risk assessment. The exception is dried beans, where DAS anticipates 100% PCT. The dried bean commodity group has demonstrated a critical need for methyl bromide for the next several years in order to transition to the use of alternatives, including sulfuryl fluoride. The US has nominated 8% of the requested amount of methyl bromide; therefore BEAD estimates 92% of dried beans may be treated with sulfuryl fluoride. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of using the higher of the two estimates, BEAD conservatively estimates 100% commodity treated.

DAS anticipated 0.1% commodity treated on other dried fruit and legumes (dried, except chickpea and cowpea). These groups did not request a methyl bromide CUE and, as BEAD is anticipating sulfuryl fluoride to replace methyl bromide, there is likely to be little use. However, in the absence of data, BEAD estimates that 69% of the other dried fruit may be treated with sulfuryl fluoride based on estimated use in similar commodities, prunes, raisins, and figs. Based on the estimated use of sulfuryl fluoride in dried beans, BEAD also estimates that 92.0 % of the other dried legumes (except chickpea and cowpea) may be treated with sulfuryl fluoride. However, for the purpose of estimating percent of commodity treated for dietary risk assessment and for consistency with BEAD's methodology of defaulting to the higher of the two estimates of the original commodity (in this case, dried beans); BEAD conservatively recommends 100.0 % commodity treated on legumes (dried, except chickpea and cowpea) (Table 9).

Cocoa bean producers have made great strides in transitioning from methyl bromide to sulfuryl fluoride, and they intend to convert 100.0 % to sulfuryl fluoride by 2010. BEAD concurs with DAS and recommends an estimate of 100.0 %.

TABLE 9. REVISED ESTIMATES OF PERCENT METHYL BROMIDE CRITICAL USE EXEMPTION COMMODITIES TREATED WITH SULFURYL FLUORIDE.

BEAD COMMODITY GROUPING	COMMODITY*	PERCENT COMMODITY TREATED *		
		DAS	BEAD	
			ESTIMATE	RECOMMENDED
METHYL BROMIDE CRITICAL USE EXEMPTION COMMODITIES	**Pistachio[1]**	**0.1 %**	**27.0 %**	**27.0 %**
	Walnuts[1]	**20.0 %**	**99.0 %**	**99.0 %**
	Dates[1]	**40.0 %**	**42.0 %**	**42.0 %**
	Prunes, Raisins, Figs[1]	**40.0 %**	**69.0 %**	**69.0 %**
	Other Dried Fruit[2, 3]	**0.1 %**	**69.0 %**	**69.0 %**
	Dried Beans[1]	100.0 %	92.0 %	100.0 %
	Legumes (Dried, except Chickpea & Cowpea)[2, 3]	**0.1 %**	**92.0 %**	**100.0 %**
	Cocoa Beans[1]	100.0 %	100.0 %	100.0 %

* Bolded text indicates BEAD's recommendations are higher than DAS estimates.

1. Based on BEAD calculations from comparative methyl bromide usage.
2. Based on estimates from similar methyl bromide critical use exemption commodities
3. BEAD's estimate is based on a commodity with a similar use pattern; therefore BEAD defaults to the higher of the two estimates of the original commodity.

Conclusion

DAS submitted studies to EPA to refine their dietary exposures for the post-harvest uses of sulfuryl fluoride. BEAD evaluated the information provided by DAS. BEAD agrees with most of the space fumigation assumptions, the exception being the number of operating days per year at mills and processing facilities. For space fumigations (grain mills and processing plants, BEAD concludes that up to 1.2% of grains could contain fluoride residues resulting from space treatments (i.e., 0.8% from treatment in mills and 0.4% from treatment in processing facilities). For all other foods (i.e., non-milled grains), the fraction resulting from space treatment is 0.4%.

For direct treatments to commodities, BEAD reviewed the information submitted by DAS. BEAD conservatively estimated Percent Commodity Treated based on current and prior methyl bromide use. BEAD finds that the DAS estimates for beef (dried), cheese, ham, coconut, coffee bean, macadamia nuts, ginger, cottonseed, corn, popcorn, herbs and spices, oats, barley, rice, sorghum, almonds, dried beans, and cocoa beans are conservative. BEAD recommends a higher percent commodity treated for millet, rice hulls, triticale, corn flour, corn grits, corn meal, peanut, wheat, beechnut, Brazil nut, butternut, cashew, chinquapin, filbert, hickory nut, pecans, pine nut, pistachios, walnuts, dates, dried fruit (prunes, raisins, figs), other dried fruit, and legumes (dried, except chickpea & cowpea).

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